

A GENETIC ANALYSIS OF SOME *EUCALYPTUS* SPECIES.

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(Plates vii-xi.)

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*Synopsis.*

Genetic analysis by progeny testing based principally on morphological seedling characters, has revealed probable F1 hybrids, and segregating swarms between several species. There is at present no evidence of hybridization between certain major taxonomic groups of the genus.

## INTRODUCTION AND METHODS.

The genus *Eucalyptus* is a complex one in which the separation of species by the ordinary taxonomic method is difficult. As it has become better known the number of described species has become more numerous. Even so, it is still easy to find individuals and even populations which do not fit any described species as well as is ordinarily the case within the majority of genera. One cause of trouble is that some of the described species cover a latitude of variation which is much smaller than that of others. In short, there has been "splitting" in some groups and not in others, and it has been somewhat cynically observed that the density of *Eucalyptus* species increases as one approaches centres of botanical study.

The past taxonomic approach in the genus has resulted in the naming, usually as species, of divergent forms of varying biological status. If this process were continued it would result in a multiplication of species which would contribute little to the understanding of the genus or to its practical classification. A more reasonable taxonomic approach involves the reclassification of many forms as geographical or ecological subspecies, but the difficulty does not end there because some of the variation is not of the geographic kind which would allow conveniently the erection of subspecies.

Some variation encountered suggests that there is active hybrid development with F2 and back-cross segregating swarms. Many of the F1 hybrids have been given specific names, e.g. *E. unialata* (Brett, 1937 and unpub.). There is another type of variation which again it is difficult to place in the category of subspecies. Eucalypt forests show always a complex mosaic pattern, one species giving way to another under very slight changes of such ecological conditions as aspect, edaphic qualities or other slight habitat changes. The one species as it occurs in successive pieces of the mosaic may show slight but fairly constant differences. Brett (1937) has termed these species *polymorphic* and suggests that the polymorphs have arisen by fixation under varying conditions of selection of segregates of previously existing swarms. The situation as he describes it shows many similarities to the introgressive hybridization of Anderson (1949). These categories of variation, if they exist, present problems for taxonomy which have so far not been satisfactorily resolved.

From accumulated knowledge of field variation of *Eucalyptus* on the Southern Tablelands and Highlands of New South Wales an attempt has been made at a genetic analysis of several of the species of this region and preliminary evidence which fully supports many of Brett's contentions has been obtained. The condition with *Eucalyptus*, Brett suggests, seems to arise from the large number of species often growing side by side, the general lack of sterility barriers between species, the stage of evolution of the genus, the effect of sub-recent climatic changes and the still more recent effect of settlement.

As luck would have it, one of the most consistent and distinctive sets of characters possessed by different species is the morphology of the juvenile leaves.

This factor permits in many cases a preliminary assessment of the genetic make-up of a plant within a few months by the simple means of growing seedlings from selected individual trees. Apart from this source, which has been the principal means of getting information, a series of preliminary experiments on controlled pollination has been carried out which has indicated clearly that hybridization in many cases is a simple matter (Pryor, 1951).

#### SEGREGATION IN OPEN POLLINATED PROGENIES.

##### *a. E. pauciflora Hybrids.*

The situation in one of the hybrids included under "*E. vitrea*" has been discussed previously (Pryor, 1950) where the individual concerned was a hybrid between *E. pauciflora* and *E. dives*. Seed was collected from a somewhat similar tree with morphological characters intermediate between *E. pauciflora* and *E. Robertsonii*. Seedlings were raised and fifty unselected plants in a block were taken from the flat and grown on in tubes (Pl. vii, fig. 2). At eight inches' height they exhibit characters showing complete segregation to parental types and intermediates (see Table 1). For some specific characters an approximation to the Mendelian ratio for the independent assortment of characters in the F2 generation is achieved. The juvenile foliage of the putative parents is quite distinct. In the case of *E. Robertsonii* (Pl. vii, fig. 1) it is narrow-lanceolate, sessile, thin, opposite for a large number of pairs, glandular hairy on the stems. In *E. pauciflora*, on the other hand, the leaves soon become petiolate and become alternate after four or five pairs, they are thick and rather broadly oblong, and the stems are almost smooth. The population obtained has some individuals which are indistinguishable from seedlings of *E. Robertsonii*, and others which cannot be separated from *E. pauciflora*. There is little doubt that the parent tree is an F1 hybrid and that the generation raised, which is probably from seed that has been produced by selfing, is an F2 generation. Similar individuals can be found almost wherever there is a junction in the field between *E. pauciflora* and *E. Robertsonii*, although they are not numerous and never form a pure stand or even a consistent major component of a stand.

In the area in which this seed was collected there was a considerable number of trees which would be considered *E. Robertsonii*. Nevertheless, though this is the only possible determination amongst described species, many of the individuals are inclined to be smooth-barked on limbs three or four inches in diameter, somewhat heavy-leaved and with fruits that are coarser than are often found on *E. Robertsonii*. From one of these trees a small amount of seed was also collected and about twelve plants were raised. While the number was small, three of the twelve plants corresponded with individuals in the progeny from the F1 hybrid which were intermediate between the two parental types. The deviation from an ordinary population of *E. Robertsonii* was far too great to do other than lead to the conclusion that the parent tree in this case could not have been "pure" *E. Robertsonii* (Pl. vii, fig. 3). Had there been no morphological indications of this, one might have concluded that some of the seed in the capsules was of hybrid origin. Since most of the flowers are probably selfed on the one tree, if not individually self-fertilized, the variation in the progeny in the light of the morphological character of the parent is consistent with what one would expect in an F3 or later generation, or from a back-cross. It is quite probable in the regrowth area concerned that there is a population containing many segregates between *E. pauciflora* and *E. Robertsonii* (Pl. viii, fig. 4) with a bias in survival towards those individuals with a preponderance of *E. Robertsonii* characteristics.

Field examination of many stands suggests that mingling between various ecotypes of *E. pauciflora* and ecotypes of Peppermints (*E. radiata*, *E. Robertsonii* and *E. dives*) is common, and this is perhaps one of the most frequent hybrid combinations found on the Southern Tablelands.

*E. pauciflora* enters into other combinations in addition. A stand was examined at Barney's Range, near Cooma, where there is an unusual occurrence side by side of *E. pauciflora* and *E. Rossii*. After some search two trees were found which were

intermediate between these two species. Seed was collected from one and 50 plants again raised without selection in pricking off from the flat. Complete segregation to the putative parents was again attained although the juvenile characteristics of these two species are not so clearly distinctive as in the previous case (Pl. viii, fig. 5). Nevertheless the trend is unmistakable and the amplitude of variation in morphological characters and the correspondence of the extreme forms closely with juvenile foliage of the recognized putative parent species is such that there is no other readily acceptable explanation than that we have an F2 population.

*E. pauciflora* has characteristics which are almost unique in the genus in its practically parallel veins in the leaves, the very thick leaves and large pyriform fruit. It appears these characters persist prominently in hybrid combination and the presence of *E. pauciflora* genes is therefore readily detected. Progeny tests are not yet complete but it is highly probable that *E. pauciflora*  $\times$  *E. delegatensis* hybrids may be readily found, and several trees are known which seem to be F1 hybrids of this combination. One tree was also found on the dividing range near Badja which looked like a hybrid between *E. pauciflora* and *E. fastigata*. On the other hand, so far no individuals have been found in the field which suggest that *E. pauciflora* enters into combination with Gums such as *E. Dalrympleana* or *E. Blakelyi*, or with Boxes such as *E. melliodora*, with all of which it can easily be found growing side by side.

b. *E. Rossii* Hybrids.

*Eucalyptus Rossii*, which, as has been mentioned, hybridizes with *E. pauciflora*, is commonly found in hybrid combination with other species. One of the commonest of these is with *E. macrorhyncha*. Using the same procedure as in the examination of *E. pauciflora* and Peppermints, a tree on Mount Jerrabomberra was examined. It has field characters intermediate between *E. macrorhyncha* and *E. Rossii*. The bark is smooth on limbs of six inches diameter or less, the fruit is rather small, with a flat-domed disc compared with *E. macrorhyncha*; the leaves are also small and shiny for "normal" *E. macrorhyncha*. The progeny obtained from seed of this tree provides a most striking example of segregation and independent assortment of many characters (Pl. viii, fig. 6). The juvenile characters of the two species are strikingly distinct. *E. macrorhyncha* (Pl. viii, fig. 7) has ovate-lanceolate or broadly elliptical leaves covered densely with "stellate" hairs. *E. Rossii* (Pl. ix, fig. 8), on the other hand, has narrow-lanceolate, glabrous, grey-glaucous leaves. This affords an outstanding example of the existence of an F1 hybrid and it is so distinctive that there is little need for further demonstration.

In the same locality seed was also collected from another tree with similar morphological characteristics. The variation in the progeny was much more restricted than in the first tree, although the trend is clearly in the same direction to the putative parents, *E. macrorhyncha* and *E. Rossii* (Pl. ix, fig. 9). The conclusion, therefore, is that though the morphological form of the parent is closely similar to that of the undoubtedly F1 hybrid, this second tree must be a member of a later filial generation or back-cross of the same hybrid combination in which the genetic variability has been considerably reduced (see also Pl. ix, fig. 10).

The existence of F1 hybrids has been established on the basis of evidence of this kind between several other pairs of species. *E. Rossii*  $\times$  *E. dives* (Pl. ix, fig. 11) is found quite frequently and progeny tests show marked segregation in some individuals, whereas other individuals closely similar morphologically show less, as in the case of *E. macrorhyncha*  $\times$  *E. Rossii* combinations.

*E. Rossii* also hybridizes freely with *E. Robertsonii* where these two species occur side by side. Blakely (ined.) proposed a variety of *E. Robertsonii* on material from the Australian Capital Territory which is close to, if not identical with, the F1 hybrid *E. Rossii*  $\times$  *E. Robertsonii*. The juvenile foliage of these two species is so distinct that segregation is at once apparent in seedlings (Pl. x, fig. 12).

*c. Miscellaneous Hybrids.*

A common hybrid combination is between *E. Robertsonii* and *E. fastigata*, and F1 individuals have been located which segregate markedly when propagated (Pl. x, fig. 14). The segregation is easily discerned because the juvenile characters of each parent are so distinct from those of the other.

Other hybrids have been found and tested between *E. Blakelyi* and *E. elaeophora* (Pl. x, fig. 15) and between *E. maculosa* and *E. elaeophora* (Pl. xi, fig. 16). Individuals are occasionally found in which the morphological characters are intermediate between *E. Blakelyi* and *E. elaeophora*. Segregation of characters is again marked in the seedling stage and the sessile, opposite, orbicular, glaucous juveniles of *E. elaeophora* are so strikingly distinct from the stalked ovate-lanceolate, green, alternate, juvenile leaves of *E. Blakelyi* that observation of segregation is quite simple. An F1 hybrid has been progeny-tested and other similar individuals have been located on Black Mountain (Pl. x, fig. 15).

Likewise, extreme differences exist between the juvenile foliage of *E. maculosa* and *E. elaeophora*, and a progeny test of an anomalous individual has given a filial population showing marked segregation to the putative parental types in the juvenile foliage (Pl. xi, fig. 16).

Another interesting individual is an undoubted F1 hybrid between *E. viminalis* and *E. glaucescens*. This individual was found on the Tinderry Ranges while examining the vegetation in company with R. G. Brett. Segregation in the progeny is easily recognized for the same reasons (Pl. xi, fig. 18).

Further combinations are being investigated but, since adequate diagnostic characters are not displayed in the juvenile forms, results will not be available until the progeny is more mature. Continued collection will produce more evidence as a wider number of species can be examined.

Table 1 shows the way in which characters have been observed to segregate in the different progenies examined.

TAXONOMIC AND EVOLUTIONARY IMPLICATIONS.

*a. Nomenclature.*

The analysis given above is still incomplete, as it is based on juvenile characters only, but problems of classification in *Eucalyptus* are profoundly affected by facts established by genetic analysis of this kind. There is little doubt that segregating swarms are common in the field and individuals from these have often been referred to species while the types of some so-called species are probably members of such swarms. The description of segregating forms as species is useless for taxonomy and the classification of such individuals should be made differently. One of the first steps in the revision of the genus *Eucalyptus* must be to determine which of the described "species" are F1 hybrids or segregates.

The position with regard to hybrids known as "*Eucalyptus vitrea*" has been discussed previously and some additional similar or related matters have been disclosed in the present study. For example, the F1 hybrid and the segregate between *E. Rossii* and *E. macrorhyncha* have both in the past been referred to *E. brevirostris*. Comparison of the material from the mature trees with the type of *E. brevirostris* shows that neither of these can be placed with that type, although they have some characters in common, notably the buds and the general fruit size. However, the rim of the fruit is quite different and the leaves are also different. There are some characters in *E. brevirostris* which suggest affinity with *E. regnans* on the one hand and a Stringybark on the other. The record of distribution of this species also suggests that it might well be a hybrid, as indeed Blakely himself supposed. It cannot, however, be a hybrid between *E. macrorhyncha* and *E. Rossii*. There is no type, therefore, with which the F1 hybrid *E. macrorhyncha*  $\times$  *E. Rossii* corresponds. It is undescribed at present, and in any case should not be described as a species.

Another hybrid combination of particular interest is that of *E. fastigata* and *E. Robertsonii*. This illustrates one way in which the genetic approach has a marked

TABLE I.  
Table of Presumptive *P1* Hybrids.

Characters Segregating in Progeny.

Presumptive Parents.	Characters Segregating in Progeny.						Other Characters.	Remarks.
	Shape.	Petiole.	Colour.	Venation.	Arrangement.	Hairs.		
<i>E. pauciflora</i> Sieb. ex Spreng. $\times$ <i>diversifolia</i> Blakely.	Yes.	Yes.	Yes.	Yes.	Yes.	Yes.	—	Yes.
<i>E. pauciflora</i> Sieb. ex Spreng. $\times$ <i>Robertsonii</i> Blakely.	Yes.	Yes.	—	Yes.	—	Yes.	—	Yes.
<i>E. pauciflora</i> Sieb. ex Spreng. $\times$ <i>Rossii</i> R. T. Bak. & H. G. Sm.	Yes.	—	—	Yes.	—	Yes.	—	No.
<i>E. pauciflora</i> Sieb. ex Spreng. $\times$ <i>delegatensis</i> R. T. Bak.	Yes.	—	—	Yes.	—	Yes.	—	No.
<i>E. Rossii</i> R. T. Bak. & H. G. Sm. $\times$ <i>macrocarpa</i> F. Muell. ex Benth.	Yes.	—	Yes.	Yes.	—	No.	Yes.	—
<i>E. Rossii</i> R. T. Bak. & H. G. Sm. $\times$ <i>disregardii</i> Schau.	Yes.	Yes.	—	No.	Yes.	—	—	Yes.
<i>E. Rossii</i> R. T. Bak. & H. G. Sm. $\times$ <i>Robertsonii</i> Blakely.	Yes.	Yes.	Yes.	No.	Yes.	Yes.	—	Yes.
<i>E. Robertsonii</i> Blakely $\times$ <i>fastigata</i> Deane & Maiden.	Yes.	Yes.	—	Yes.	—	Yes.	—	Yes.
<i>E. fastigata</i> Deane & Maiden $\times$ <i>macrocarpa</i> F. Muell. ex Benth.	Yes.	—	—	Yes.	—	Yes.	—	No.
Macarandberae.								
<i>E. Blakelyi</i> Maiden $\times$ <i>cladophylla</i> F. Muell.	Yes.	Yes.	—	Yes.	—	No.	—	No.
<i>E. cladophylla</i> F. Muell. $\times$ <i>mauritosa</i> R. T. Bak.	Yes.	Yes.	No.	No.	—	No.	—	—
<i>E. viminifolia</i> Labill. $\times$ <i>glaucescens</i> Maiden & Blakely.	Yes.	—	Yes.	No.	—	—	—	No.

*Explanation*: Yes = segregation observed. No = segregation possible but not observed. — = characters similar in the two presumptive parents—segregation impossible to observe.

bearing on taxonomic conclusions. *E. radiata* and *E. Robertsonii* were regarded as distinct species by Blakely. One of the means of separation of these species is the appearance of sub-parallel venation in *E. radiata* as distinct from *E. Robertsonii*. The two species are obviously very closely related.

The presence of hybrids and segregates of *E. fastigata* and *E. Robertsonii* in the field accounts for the sub-parallel venation which is sometimes found in areas where the trees correspond generally with *E. Robertsonii*. One of the uncertainties which has led to the suggestion that *E. Robertsonii* and *E. radiata* should not be separated as distinct species is removed if it is recognized that this lack of consistency between the two species is, in the case of *E. Robertsonii*, a result of hybrid influence by *E. fastigata*, and the decision as to whether the two are "good" species rests on whether the two populations are sufficiently distinct.

There is no doubt that the type of *E. Robertsonii* which was collected by Blakely and de Beuzeville on Talbingo Mountain represents the population of the western part of the Southern Highlands, which has a number of characters different from *E. radiata*, the type of which comes from the Blue Mountains. These characters, though not marked, are nevertheless fairly distinctive. It seems, therefore, that *E. radiata* and *E. Robertsonii*, according to the definitions accepted in the concept, could be regarded either as species or alternatively as subspecies within the *E. radiata* group.

On the other hand, the position of *E. Westonii* is similar to that of *E. vitrea*. The hybrid between *E. maculosa* and *E. elaeophora* is identical with *E. Westonii*, the type locality of which is Mt. Majura, A.C.T.

In the vicinity of the type tree there are populations of segregates which vary more or less continuously between each of the supposed parents. There is little doubt that *E. Westonii* is an F1 hybrid between *E. maculosa* and *E. elaeophora* and that it is in consequence genetically unstable. It therefore should not be regarded as a species.

#### b. "Phantoms" and Clines.

The detection of the F1 hybrid between *E. Rossii* and *E. Robertsonii* has already been described where stands of these two species are side by side in the field; however, in other areas somewhat remote from stands of *E. Robertsonii* individuals are found which are intermediate between *E. Rossii* and a Peppermint of the *E. radiata* type. Usually there is no *E. radiata* or *E. Robertsonii* present, as at Black Mountain, A.C.T., and Mt. Jerrabomberra, N.S.W., but the progeny from the tree shows a limited degree of segregation which unmistakably reveals genetic diversity beyond that which is normal in one of the accepted species (Pl. x, fig. 13). The best explanation for such occurrences is that given by Brett (1949). He supposes that the genes of the *E. radiata* are preserved in hybrid form to some extent as a relict from former times when, probably due to somewhat different climate, the *E. radiata* was much more widely distributed. Brett has referred to such occurrences as a "phantom" of a species, and this appears to be quite apt. The same condition has been found with *E. fastigata* genes preserved in *E. macrorhyncha* on Mt. Macdonald, A.C.T. (Pl. ix, fig. 10). This aspect must be studied more closely as information which relates critically to the subject becomes available from the trials in progress.

*E. Rossii* also presents another phase of the same condition in that it appears to contain, in many instances, genetic influence in varying degrees from Peppermints and Stringybark species which could be expected as climatic changes and conditions for survival of some species become more difficult. *E. Rossii* shows minor variations in populations from place to place, apparently for this reason. Again this aspect must be treated separately when more experimental data are available.

Another distinct condition resulting from gene movement is illustrated in the clinal variation in *E. fastigata* and *E. radiata*.

The hybrid *E. radiata* × *E. fastigata* is common on the dividing range in the vicinity of Badja and in this locality exhibits an interesting feature. On the gentler grading sheltered slope on the western fall of the range *E. radiata* is confined to a narrow strip near the crest. At this point also hybrids of *E. fastigata* occur. As one then proceeds

down the slope, narrow-leaved, small-fruited forms of *E. fastigata* occur which gradually become coarser and pass without discontinuity to typical *E. fastigata* in the middle and lower parts of the slope. This variation in a cline according to exposure grades from a form intermediate between the two parent species to *E. fastigata*. A clinal sequence from the intermediate to *E. radiata* is not to be found in this locality, presumably because the site favours the combination on the *E. fastigata* side of the mode of the hybrid combination.

The same kind of clinal variation in individuals was observed from the area of the occurrence of the F1 hybrid *E. pauciflora*  $\times$  *E. Rossii*, the gradation being from this form to *E. Rossii* as the conditions become warmer.

c. *Gene Invasion.*

The evidence produced in the examination of *E. glaucescens* suggests that gene invasion of this species by *E. viminalis* is a likely explanation of the facts.

*E. glaucescens* is an uncommon species which occurs in small communities on rocky areas in sub-alpine regions. It has close affinity with two Tasmanian species, *E. Gunnii* and *E. urnigera*. This relationship and its scattered distribution suggest that it is a relic of a group of species or a common precursor which flourished at some earlier period in the south-east highlands and in Tasmania. Wherever it is in contact with *E. viminalis* (and this is probably usual) it is being hybridized and invaded by the more successful genes of that species. The evidence for this is that in the small progeny test segregates intermediate in character between the apparent F1 hybrid and the typical *E. glaucescens* are of low viability, whereas those segregates leaning to *E. viminalis* are highly successful (Pl. xi, figs. 18 and 19). If this is so, it is an illustration of gene invasion referred to by Brett (1950) and is one way in which a species can be virtually extinguished. Specimens of *E. glaucescens* collected by A. B. Costin near the Victorian border have produced some plants tending towards *E. viminalis* (Pl. xi, fig. 19), thus clearly indicating the presence of the genes, though the parent could not be taken for *E. viminalis*, and it could not be an F1 hybrid because of the absence of segregation of the type expected in an F2 generation.

With *E. Perriniana*, by way of contrast, the position is quite the reverse. It is a species of similar sub-alpine distribution, but, where examined, no trace of hybrids can be found. While it is apparently a diminishing relic population, now occurring only on hard sites, simple competition from more vigorous species appears to be the cause of its near extinction.

d. *Sterility Barriers.*

The evolution of the genus and the possible extent of the conditions described above will be strictly limited by any barriers to breeding within the genus. These are not yet fully known, but field occurrences suggest that hybridization is, at least under natural conditions, confined within the major taxonomic divisions of the genus as given by Blakely. Experimental controlled pollinations confirm this in general terms but not absolutely (Pryor, 1951).

On the other hand, Brett (1937) says there is some evidence of intergroup hybrids, as, for example, *E. ovata*  $\times$  *E. pauciflora*, and *E. risdonii*  $\times$  *E. viminalis*.

While there is perhaps evidence of selection of similar characters, e.g., large leaves or glaucousness, in unrelated species growing side by side in a particular habitat, a careful search has so far failed to produce one of the wide crosses between the three taxonomic groups, Macranthae, Renantherae and Terminales, which often occur side by side in the field on the Southern Highlands.

More critical work is necessary to establish the limits and such points as whether such progeny is viable or, if so, whether it is fertile.

SUMMARY.

A genetic examination, principally by progeny testing, has been made of several species common on the Southern Highlands of New South Wales and in Victoria. Morphological seedling characters are of critical diagnostic value in the genus *Eucalyptus*

and the segregation of some of these characters in progenies strongly suggests that a number of the individuals examined are F1 hybrids. Other individuals similar in their general morphology are revealed as probably hybrid but of a later filial or back-crossed generation.

From the evidence obtained by progeny tests it is considered likely that segregating swarms between well-established species occur in a number of cases. Under field conditions hybridization between three of the major taxonomic groups of the genus *Eucalyptus*, namely, Macrantherae, Renantherae, and Terminales, as given by Blakely, has not been observed and it is considered that this, though perhaps possible, is unlikely. Further work is in progress to examine the position with regard to other species combinations and to examine various aspects of genetic behaviour within the genus.

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#### EXPLANATION OF PLATES VII-XI.

##### Plate vii.

Fig. 1.—*E. Robertsonii*. Progeny showing slight variation characteristic of a population falling within the defined limits of the species without hybrid influence.

Fig. 2.—*E. pauciflora* × *E. Robertsonii*, Cotter House, A.C.T. An F2 generation raised from a probable F1 hybrid. Segregation is complete and there is independent assortment of characters. The extreme left is identical with *E. Robertsonii* and the extreme right is *E. pauciflora*. The development of broad leaves, but practically sessile and opposite, in the fifth from the left, is a mixture of *E. pauciflora* and *E. Robertsonii* characteristics, whereas the petiolate leaves but relatively narrow, is a mixture of *E. pauciflora* and *E. Robertsonii* characteristics of a different degree. The development of alternate leaves is noticeable in the final pair, especially of the fourth from the left and the seedling on the extreme right.

Fig. 3.—*E. Robertsonii*, Cotter House, A.C.T. There is unmistakable *E. pauciflora* in this population, as is indicated by the seedling on the extreme left. The second from the left shows thick and broad leaves but retains the Peppermint character of sessile, opposite leaves. The seed parent of these seedlings appears to be Peppermint (*E. Robertsonii*) but was rather clean-stemmed and with larger fruits and somewhat heavier leaves than is "normal". It clearly contains *E. pauciflora* genes.

##### Plate viii.

Fig. 4.—*E. pauciflora*, Cotter House, A.C.T. This shows a tendency to *E. Robertsonii*, particularly in the individual at the extreme left. The leaves are narrower and inclined to be sessile and opposite to an extent greater than that characteristic of *E. pauciflora*, which is typical in the two individuals on the right. The parent of this population, however, must have been part of a hybrid swarm between *E. Robertsonii* and *E. pauciflora*.

Fig. 5.—*E. pauciflora* × *E. Rossii*. An F2 generation raised from an apparent F1 hybrid from Barney's Range. The thick broad-lanceolate leaves of the plants on the left stand sharply in contrast with the narrow-lanceolate, rather thin-stemmed and thin-petioled leaves on the right. Characters which are more critically distinct may be expected to appear as the trees become older, the juvenile characters being in this pair of species rather more similar than in many others.

Fig. 6.—*E. macrorhyncha* × *E. Rossii*. An F2 population showing complete segregation from *E. macrorhyncha* type on the left to *E. Rossii* on the right. Note the change in leaf shape and petiole length. The indumentum of "stellate" hairs characteristic of *E. macrorhyncha* shows a similar gradation. There is a marked tendency for the intermediate hybrid type (similar in form to the F1 hybrid), third from the left, to be the most vigorous.

Fig. 7.—*E. macrorhyncha*. A population characteristic of the species showing the typical leaf shape and at times slightly crenate leaf margins.

##### Plate ix.

Fig. 8.—*E. Rossii*, Jerrabomberra. A population without hybrid influence showing relatively uniform characteristics of the progeny.

Fig. 9.—*E. macrorhyncha* × *E. Rossii*. Progeny from a tree which was not an F1 hybrid, showing a type tending to *E. macrorhyncha* in the plants at the left, and a type approaching *E. Rossii* in the types at the right. Compare with Fig. 7, where the segregation runs from one putative parent to the other, indicating a broader range of variation.

Fig. 10.—Progeny from an apparent *E. macrorhyncha* hybrid, Mt. McDonald, A.C.T. The progeny suggests strong affinity with *E. fastigata* in the form on the right-hand side. The two individuals at the left are closely similar with normal *E. macrorhyncha*. The fourth from the left is roughly intermediate between *E. macrorhyncha* and *E. fastigata*. This suggests the preservation of *E. fastigata* genes in hybrid combination in a locality in which *E. fastigata* no longer exists.

Fig. 11.—*E. dives* × *E. Rossii*. Note the broad, opposite, sessile leaves on the plant on the left, grading to lanceolate, petiolate leaves approaching *E. Rossii* on the right. The fourth from the left is becoming distinctly alternate. Probably not an F<sub>2</sub>, but a later generation however.

Plate x.

Fig. 12.—Progeny from a parent belonging to the hybrid swarm *E. Rossii* × *E. Robertsonii*. The plant on the left is close to *E. Robertsonii*. Note the progressive development of stalked leaves becoming alternate as one proceeds to the right, a generation later than an F<sub>2</sub> generation.

Fig. 13.—Progeny from a tree on Mt. Jerrabomberra of a narrow-leaved Peppermint type. Appears to be clearly a hybrid between a Peppermint of the *E. Robertsonii* or *E. radiata* type and *E. Rossii*, the characters of the putative parents being shown in the gradation from left to right, the Peppermint being at the extreme left. The fifth from the right, however, indicates a probable influence of *E. dives*, showing that this is not a simple hybrid. The occurrence of this tree is remarkable, as there are no *E. dives*, *E. radiata* or *E. Robertsonii* now on Mt. Jerrabomberra. The trees from which the seed was taken to raise these plants are about 30 years old and appeared following disturbance in road making about 30 years ago.

Fig. 14.—Progeny from an F<sub>1</sub> hybrid between *E. fastigata* and *E. Robertsonii*. Arranged to show the sequence of characters from *E. fastigata* on the left to *E. Robertsonii* on the right. Note the change from alternate, petiolate broad-lanceolate leaves at the left, to opposite, sessile narrow-lanceolate leaves on the right.

Fig. 15.—Progeny from a hybrid between *E. elaeophora* and *E. Blakelyi*. Showing complete segregation between the two putative parents, *E. elaeophora* on the left with opposite, orbicular, sessile leaves, to *E. Blakelyi* with petiolate, broad ovate-lanceolate, alternate leaves at the right. Note the gradations of characters between the two extremes and also the lack of vigour in the intermediate types.

Plate xi.

Fig. 16.—Progeny from *E. Westonii*, Black Mountain, A.C.T. Indicating three main gene types. At the extreme left, a Blue Gum resembling *E. goniocalyx*, and the centre, types tending to *E. elaeophora* or *E. Bridgesciana*, and at the right, *E. maculosa*. A complex gene mixture that needs further analysis. A variation in vigour of the various combinations is also interesting.

Fig. 17.—*E. glaucescens* × *E. viminalis*. Seedlings raised from a supposed F<sub>1</sub> hybrid from the Tinderry Mountains. Photographed in November, 1949. Compare with Fig. 18, in which the order of arrangement is reversed, *E. glaucescens* being at the extreme right. The plant second from the left, which is showing signs of weakness, is the second from the right in Fig. 18 and is, in the six months' interval, dead.

Fig. 18.—*E. glaucescens* × *E. viminalis*—progeny raised from a supposed F<sub>1</sub> hybrid collected on the Tinderry Mountains. Note the segregation in the seedlings in the F<sub>2</sub> generation between *E. viminalis* type at the extreme left and *E. glaucescens* at the right. Photograph taken in May, 1950, indicating the difficulty in raising segregates which approach *E. glaucescens*, the fourth from the left being almost dead. Compare this plant with the same individual in Fig. 17, which is the same population of five plants taken in November, 1949.

Fig. 19.—Progeny from a tree of *E. glaucescens* showing the presence of *E. viminalis* genes. The seed was collected by Mr. A. B. Costin from a tree, apparently *E. glaucescens*, at Tingiringi. The unmistakable influence of *E. viminalis* is apparent in the two individuals at the right.